Geotextiles and Geomembranes 29 (2011) 74–82

Contents lists available at ScienceDirect

Geotextiles and Geomembranes

journal homepage: www.elsevier.com/locate/geotexmem

PVD improvement combined with surcharge and vacuum preloading including simulations

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ARTICLE INFO

Article history:
Received 25 November 2009
Received in revised form
18 May 2010
Accepted 12 June 2010
Available online 17 September 2010

Keywords:
Prefabricated Vertical Drain (PVD)
Geosynthetics
Vacuum preloading
Bangkok clay
Ground improvement

ABSTRACT

This paper presents the study of PVD improved reconstituted specimen with and without vacuum preloading on large-scale consolidometer in the laboratory tests. Subsequently, the results of the laboratory tests were analyzed and simulated by 2D (axisymmetric) finite element method (FEM) to back-analyze and confirm the related design parameters which were used further in subsequent numerical experiments. The laboratory test results indicated that the increased hydraulic conductivity in the smear zone of PVD with vacuum preloading (Vacuum-PVD) resulted in the increase in the coefficient of horizontal consolidation (*Ch*) by 16% as well as the decrease in the ratio between the horizontal hydraulic conductivity of the undisturbed zone (*Kh*) to the horizontal hydraulic conductivity in the smear zone (*Ks*) or (*Kh*/*Ks*) of about 10%. The Vacuum-PVD and PVD only have the same settlement magnitudes with similar equivalent loads.

1. Introduction

Vacuum consolidation (or vacuum preloading) is a soft ground improvement method that has been successfully used by geotechnical engineers and specialists to accelerate the rate of consolidation and to eliminate the instability problem using the conventional prefabricated vertical drains during the embankment preloading. The prefabricated vertical drain combined with vacuum pressure is applied to further enhance the rate of consolidation and shorten the construction periods (Chu et al., 2000; Chai et al., 2005; Liu and Chu, 2009; Liu et al., 2009). The vacuum consolidation was proposed in the early 1950 by Kjellmann (1952), the developer of the prefabricated vertical wick drain. The studies of vacuum induced consolidation continued up to the present (Holtz, 1975; Choa, 1989; Cognon et al., 1994; Bergado et al., 1998, 2006; Tang and Shang, 2000; Chai and Miura., 2000; Mohamedelhassan and Shang, 2002; Indraratna et al., 2004, 2005; Chai et al., 2005, 2006, 2007, 2008; Yan and Chu, 2005; Walker and Indraratna, 2006, 2009; Rujikiatkamjorn and Indraratna, 2007; Rujikiatkamjorn et al., 2007, 2008; Saowapakpiboon et al., 2008a, b, 2009, 2010). Vacuum consolidation preloads the soil by reducing the pore pressure while maintaining constant total stress instead of increasing the total stress. The effective stress is increased due to the reduced atmospheric pressure in the soil mass. The net effect is an additional surcharge ensuring early attainment of the required settlement and an increased shear strength resulting in increased embankment stability. Moreover, the vacuum preloading technique can reduce the large quantity of surcharge fill material and its associated instability problem.

2. The laboratory test using PVD with and without vacuum

2.1. Test specimens

The soil samples used in this study were obtained from site located at the Second Bangkok International Airport (SBIA) or Suvarnabhumi Airport which is located at Samut Prakarn Province of Thailand at about 30 km southeast of Bangkok. The soft clay samples were collected from 3.0 to 4.0 m depth and placed in covered containers. Table 1 tabulates the physical properties of the soft Bangkok clay samples. The PVD material used was CeTeau drain (CT-D911) and the PVD properties are summarized in Table 2.

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0266-1144/$ – see front matter © 2010 Published by Elsevier Ltd.
doi:10.1016/j.geotexmem.2010.06.008